Performance of Cream or Compressed Yeast in Frozen and Nonfrozen Doughs[1]

P. GÉLINAS, M. LAGIMONIÈRE, and N. RODRIGUE

ABSTRACT

Cereal Chem. 71(2):183–186

When tested in nonfrozen and frozen doughs, the gassing power and freeze-thaw tolerance (rapid freezing without storage period; slow freezing followed by storage for 12 weeks) of eight cream yeasts and eight compressed yeasts obtained from two commercial sources varied significantly according to yeast batch. When tested fresh, gassing power and freeze-thaw tolerance of cream yeasts were equivalent to those of compressed baker's yeasts. Cream yeasts and compressed yeasts had also similar keeping properties, but this factor varied significantly from batch to batch (loss of activity ranging from 1 to 21%). However, storage of yeast batches for three weeks at 4°C did not change their relative freeze-thaw tolerance, as compared to gassing power in the fresh state (no dough pre-fermentation before freezing).

In frozen-dough manufacturing, yeast survival and gas retention in dough are major problems. Technological solutions have been proposed by the yeast industry. For example, frozen baker's yeast containing intermediate dry matter content has been patented by Goux and Clément (1987). Special yeast strains have also been screened according to their freeze-thaw tolerance (Hino et al 1987, Hahn and Kawai 1990).

Recently baker's yeast has also been available commercially in the liquid form, cream yeast. Cream yeast contains about 18% solids, compared to about 30% for compressed yeast (Trivedi et al 1989). Production of cream yeast is similar to that of compressed yeast, except that the process is stopped just before final dewatering and extrusion, and the cream yeast is not filtered by a rotary vacuum and extruded. This processing step has a stressing effect for yeast. Heat is created, and the cooling process is lengthened by three to four days because heat transfer is poor in compressed yeast (Van Horn 1989). For large bakeries, cream yeast remains a very good choice, mainly because it can be pumped. The concept of using yeast in the liquid form (cream) rather than in compressed form was developed to improve consistency of yeast activity. To standardize the gassing activity, the solids content of cream yeast can be adjusted at the production plant, but this cannot be done with compressed yeasts, which are packed immediately after production. Cream yeast is also said to have better keeping properties during storage in the bakery. A better dispersion during dough mixing is another advantage expected in conventional breadmaking and frozen dough manufacturing (Van Horn 1989).

In a companion study, we have shown that compressed yeast samples found on the market vary widely according to their freeze-thaw tolerance, even for a given supplier or trademark (Gélinas et al 1993). However, the reasons for such fluctuations are not known. The main differences between cream yeast and regular compressed baker's yeast are in their final processing steps (filtration and extrusion). Cream yeast is considered to be less stressed than is compressed yeast. The cream yeast found on the market may differ from the compressed yeast in frozen doughs, which are produced in a most stressing breadmaking procedure for yeast. In this study, we compared cream and compressed yeast batches from two yeast suppliers in both nonfrozen and frozen doughs. We also evaluated the effect of storage for three weeks at 4°C on yeast gassing power and relative freeze-thaw tolerance.

MATERIALS AND METHODS

Commercial Yeast Samples

Sixteen commercial baker's yeast batches were obtained from two different suppliers (four cream and four compressed from each). Yeasts were tested within two to four days after manufacturing and were kept at 4°C throughout the study.

Breadmaking Procedure

Yeast samples in dough were tested both while fresh and after storage for three weeks at 4°C. Dough was prepared in duplicate according to the no-time dough process using the following formula (1,000-g flour basis): flour (hard red spring wheat, 12.6% protein), 100; water, 59; sugar, 4; shortening, 3; salt, 2; yeast, 0.9 (dwb); ascorbic acid, 100 ppm; potassium bromate, 60 ppm. All dry ingredients were mixed for 1 min at low speed in a Hobart mixer A 200-20. The rest of the ingredients were then added and slowly mixed for 1 min. Intense mixing (speed 2) was done for 12 min. Dough (25°C) was divided by hand into five 330-g portions.

Freezing Tests

Yeast fermentative activity in nonfrozen doughs and freeze-thaw tolerance were determined simultaneously. Two freezing procedures were used: rapid (about 10°C/min, without storage and thawed rapidly) and slow (1°C/min, followed by storage at −30°C for 12 weeks and thawed slowly).

Rapid freezing test. The first dough was divided into twelve 25-g pieces that were used as the control (nonfrozen doughs) and in the rapid freezing test. Half of the dough pieces were immediately rounded by hand, placed into jars (Risograph, RDesign, Pullman, WA), and put into a water bath at 38°C. Gas production readings were registered every 2 min for 90 min. The six other dough pieces were rolled by hand into cylinders, placed into plastic bags, slightly pressed by hand, and then sheeted mechanically. Bags containing doughs were then attached to a metallic rack and submerged in an ethanol bath at −45°C for 20 min. Each frozen sheet of dough was broken in two, removed from bags, and placed into a Risograph jar. Closed jars (not connected) were left for 15 min in the water bath at 38°C before the 90-min collection of data was started. Gas production from frozen-thawed doughs and nonfrozen doughs was compared. Results from duplicates were pooled and expressed as percentage of residual performance.

Storage test. The four remaining 330-g doughs were rounded mechanically. After resting for 10 min at room temperature, they were sheeted through sheeting rolls set at 9 mm, molded with a sheeter-molder (L&M Co., Ltd., Downsview, ON, Canada). Doughs were frozen at −50°C for 45 min in a cryogenic freezer (Ultrafrost, Küleg, Germany), placed into double plastic bags, and stored for 12 weeks at −30°C. Upon completion of the storage time, thawing was done on two different days (two series of two doughs each). Each time, two doughs were placed in cardboard

---

[1] Contribution 308 from the Food Research and Development Centre, Agriculture and Agri-Food Canada, St. Hyacinthe, Quebec, Canada J2S 8ES.

container, along each side of the box, between two plastic bags. They were kept at 0–2°C for 16 hr or until the temperature at dough center was 0–2°C as measured with a thermometer. Thawed dough was divided into six 25-g portions, each rounded by hand and deposited into Risograph jars. These jars were closed and placed in the water bath at 38°C. Gas production measurements were started immediately after the jars were connected to the Risograph instruments. Pooled data from two repetitions of six Risograph readings after 90 min of fermentation for doughs thawed on two different days, were divided by the mean of six readings for nonfrozen doughs (control) obtained from the rapid test described above. Results were expressed as percentage of residual performance (gassing power).

Yeast Dry Weight

Yeast (5 g) in an aluminium weight boat was diluted with 5 ml of 70% ethanol solution, dried at 110°C for 4 hr, and cooled. The resulting dried yeast sample was weighed. All tests were performed in triplicate.

Statistical Analysis

The statistical design was a two-stage nested design, with *yeast batches* (samples) nested within *yeast suppliers* (trademarks). In certain multifactor experiments, the levels of one factor are similar, but not identical, for different levels of another factor. Such an arrangement is called a *nested* or *hierarchical* design. The levels of yeast batch factor nested under the levels of yeast supplier factor (Hicks 1982, Montgomery 1991).

For the analysis of gas production in nonfrozen doughs (Table I) and residual gas production in doughs frozen rapidly (Table II), we used a mixed model where suppliers were fixed and batches were random effects. For the analysis of residual gas production in doughs frozen slowly and stored for 12 weeks (Table III), the statistical model followed a three-stage nested design because the thawing was done on two different days. It was also a mixed model; suppliers and days were fixed, and batches were random effects. For this set of data (Table III), only three samples (batches) per supplier have been analyzed.

In Tables I and II, some responses were transformed to their base 10 logarithms before the statistical analysis to stabilize the variance and normalize the residuals. In addition to the analysis of variance, we have estimated the variance component of the sources of variation in the model. Multiple comparisons were performed on least squares means, so that probability of committing type I error was fixed at an $\alpha = 0.05$ level.

RESULTS AND DISCUSSION

Gas Production in Nonfrozen Doughs

In nonfrozen doughs, significant differences were observed between gassing power of the 16 commercial yeast batches when tested fresh ($P = 0.0001$) (Table I). Variation between yeast batches, within a supplier and type, explained 92% of total variability. On the whole, gassing power of cream and compressed yeasts were not significantly different ($P = 0.3723$). However, gassing power of the cream yeast batches from supplier 1 (cream 1) varied more than that of the three other yeasts (cream 2, compressed 1, and compressed 2).

After storage for three weeks at 4°C, gassing power dropped about 10% for both cream and compressed yeasts. Major variations (1–21%) were observed between some batches. Whatever the supplier, both cream and compressed yeasts had similar gassing power and keeping properties at 4°C, mainly because of the great variability observed among yeast batches ($P = 0.2088$). Kline and Sugihara (1968) also observed differences in keeping properties at 4°C of two yeast samples from different suppliers. Edelmann et al (1981) showed that loss of gassing power during storage at 4°C is related to the loss of carbohydrate reserves, trehalose, and glycogen. However, reasons for such differences in yeast-keeping properties at 4°C are still obscure.

Results from Table I were obtained on the basis of yeast solids content (0.9 g) in the bread formulation. In practice, one may refer to the wet weight of yeast in the formulation, that is 5 g of cream yeast at 18% solids or 3 g of compressed yeast at 30% solids. Because gas production in dough is a direct function of the yeast concentration in dough (results not shown), we have transformed data from Table I on the basis of wet weight of yeast rather than dry weight. Unfortunately the use of data based on wet weight increased the variability among batches and jeopardized the respect of the assumptions underlying the use of analysis of variance. Because of this, statistical analysis of data on the basis of wet weight of yeast was not possible.

Residual Gas Production in Frozen-Thawed Doughs

Gas production of yeast batches was reduced markedly either after rapid freezing without storage (Table II) or after slow freezing

TABLE I

Gas Production in Nonfrozen Doughs of Yeast Prestored at 4°C[a]

								Loss of Gassing Power (%)			
				Fresh		Stored 3 Weeks		Batch		Supplier	
Type	Supplier	Batch	Solids Content (%)	Batch	Supplier	Batch	Supplier	Original Scale	Transformed[b]	Original Scale	Transformed
Cream	1	1	18.56	153.3 b–e	145.7 a	139.2 ab	133.1 a	9.1 a–d	1.0	7.1 a	0.9
		2	16.77	160.7 ab		137.6 ab		14.2 b–d	1.2		
		3	18.88	146.9 ef		138.1 ab		5.9 a–c	0.8		
		4	20.36	121.8 i		117.6 d		3.4 a	0.5		
	2	1	19.83	148.1 d–f	156.0 a	140.4 ab	139.2 a	5.1 ab	0.7	9.7 a	1.0
		2	19.00	159.1 a–c		144.3 a		9.3 a–d	1.0		
		3	19.54	148.1 d–f		132.0 a–c		10.8 b–d	1.0		
		4	18.00	168.7 a		140.0 ab		17.0 d	1.2		
Compressed	1	1	31.60	134.8 gh	141.2 a	126.7 b–d	130.7 a	5.7 a–c	0.8	8.5 a	0.9
		2	32.57	150.3 c–f		139.3 ab		7.3 a–d	0.9		
		3	32.38	149.6 c–f		127.4 b–d		14.8 cd	1.2		
		4	34.03	130.0 hi		129.4 b–d		(0.5)[c]	...		
	2	1	35.27	149.4 c–f	149.9 a	118.3 cd	131.1 a	20.5 d	1.3	11.4 a	1.1
		2	32.95	143.2 fg		131.0 a–d		8.2 a–d	0.9		
		3	31.97	157.0 b–d		138.3 ab		11.5 b–d	1.1		
		4	33.56	149.9 c–f		136.8 ab		8.7 a–d	0.9		
Standard Error			...	1.5	5.7	2.2	4.0	...	0.1	...	0.1

[a] Least squares means with the same letter are not significantly different within each column ($\alpha = 0.05$). Gas volume (ml) means were calculated from two observations (one observation = mean of six Risograph readings).

[b] Logarithmic transformation applied to stabilize variance.

[c] Not included in the statistical analysis because of outliers.

followed by storage at −30° C (Table III). For both freezing conditions, there were major variation of freeze-thaw tolerance between commercial yeast batches, whatever the supplier or yeast type (cream or compressed). These results confirm our previous study (Gélinas et al 1993). We now extend these conclusions to cream yeast because, in general, we did not have enough evidence that it performed better than compressed yeasts in frozen doughs, mainly because of large variations among yeast batches.

Whatever the freezing conditions (Tables II and III), yeast percentage of residual gas production did not change much with yeast prestorage for three weeks at 4° C, considering that original gas production dropped (Table I). Therefore, storage of yeast at 4° C before the preparation of frozen dough did not in any way improve the freeze-thaw tolerance of most of the cream or compressed baker's yeast samples tested in this study. These results indirectly confirm observations made by Tanaka et al (1980) that showed when dough is not pre-fermented before freezing, prestorage of yeast for up to 82 days did not improve its freeze-thaw tolerance. In our study, dough was not pre-fermented before freezing because dough is not prepared that way for frozen-dough manufacturing in Canada or the United States. On the contrary, several authors have shown that, when dough pre-fermentation before freezing is performed, yeast storage before freezing had an improving effect on yeast freeze-thaw tolerance (Kline and Sugihara 1968, Hsu et al 1979, Tanaka et al 1980). Even when cream and compressed yeast samples tested in this study were not from the same original batch, our results suggest that the finishing steps of yeast manufacturing (filtration and extrusion) do not have much effect on gassing power, yeast-keeping properties at 4° C, and freeze-thaw tolerance in dough. In fact, growth conditions have been shown to be a major factor for yeast survival to freeze-thaw (Gélinas et al 1989).

In conclusion, this study showed that cream and compressed yeasts have similar gassing power, yeast-keeping properties at 4° C, and freeze-thaw tolerance in dough. The possible differences are likely to be masked by major, but obscure, batch-to-batch variations, whatever the yeast supplier. Prestorage of baker's yeast at 4° C for three weeks did not affect its freeze-thaw tolerance in frozen doughs (no dough pre-fermentation period before freezing).

TABLE II

Residual Gas Production (%) in Frozen-Thawed Doughs After Rapid Freezing of Yeast Prestored at 4° C[a]

			Fresh				Stored 3 Weeks	
			Batch		Supplier			
Type	Supplier	Batch	Original Scale	Transformed[b]	Original Scale	Transformed	Batch	Supplier
Cream	1	1	54 (2.55) d–h	1.73 (0.02)	61 (4.36) a	1.78 (0.03)	58 (2.36) b–e	60 (5.19) a
		2	50 (1.80) f–h	1.70 (0.01)			47 (1.67) ef	
		3	66 (1.80) a–d	1.82 (0.01)			66 (1.67) a–c	
		4	77 (1.80) a	1.89 (0.01)			70 (1.67) ab	
	2	1	69 (1.80) ab	1.84 (0.01)	64 (3.90) a	1.81 (0.03)	59 (1.67) b–d	64 (4.64) a
		2	58 (1.80) b–f	1.77 (0.01)			60 (1.67) bc	
		3	67 (1.80) a–c	1.83 (0.01)			65 (1.67) a–c	
		4	62 (1.80) b–e	1.79 (0.01)			73 (1.67) a	
Compressed	1	1	56 (1.80) c–g	1.75 (0.01)	57 (3.90) a	1.76 (0.03)	47 (2.36) d–f	48 (5.19) a
		2	55 (1.80) d–h	1.74 (0.01)			43 (1.67) f	
		3	50 (1.80) f–h	1.70 (0.01)			42 (1.67) f	
		4	69 (1.80) ab	1.84 (0.01)			61 (1.67) bc	
	2	1	46 (1.80) h	1.66 (0.01)	49 (3.90) a	1.69 (0.03)	38 (2.36) f	53 (5.19) a
		2	50 (1.80) f–h	1.70 (0.01)			56 (1.67) c–e	
		3	54 (1.80) e–h	1.73 (0.01)			68 (1.67) ab	
		4	48 (1.80) gh	1.68 (0.01)			49 (1.67) d–f	

[a] Least squares means with the same letter are not significantly different within each column ($\alpha = 0.05$). Standard errors are presented in parentheses. For yeast batches and suppliers, percentage means were calculated from two and eight observations respectively (one observation = one ratio calculated by dividing mean of six Risograph readings from frozen-thawed doughs, by mean of six readings from nonfrozen doughs).

[b] A logarithmic transformation was applied to stabilize variance.

TABLE III

Residual Gas Production (%) in Frozen-Thawed Doughs (After Slow Freezing and Storage for 12 Weeks) of Yeast Prestored at 4° C[a]

			Fresh		Stored 12 Weeks	
Type	Supplier	Batch	Batch	Supplier	Batch	Supplier
Cream	1	2	68 (1.07) b–d	72 (3.06) a	66 (0.93) cd	71 (2.05) a
		3	71 (1.07) a–d		74 (0.93) ab	
		4	77 (1.07) a		74 (0.93) ab	
	2	2	67 (1.07) c–e	73 (3.06) a	69 (0.93) bc	70 (2.37) a
		3	77 (1.07) a		65 (1.14) c	
		4	75 (1.07) ab		76 (1.14) a	
Compressed	1	2	60 (1.07) e	64 (3.06) a	60 (0.93) d	64 (2.51) a
		3	60 (1.07) e		65 (1.32) cd	
		4	72 (1.07) a–c		66 (1.14) cd	
	2	2	71 (1.07) a–d	68 (3.06) a	63 (0.93) cd	67 (2.05) a
		3	69 (1.07) b–d		69 (0.93) bc	
		4	64 (1.07) de		68 (0.93) bc	

[a] Least squares means with the same letter are not significantly different within each column ($\alpha = 0.05$), according to a linear statistical model for a three-stage nested design. Standard errors are presented in parentheses. For yeast batches and suppliers, percentage means were calculated from four and twelve observations respectively (one observation = one ratio calculated by dividing mean of six Risograph readings from frozen-thawed doughs, by mean of six readings from nonfrozen doughs).

ACKNOWLEDGMENTS

We would like to thank Michel Leverne and Roger Beurier from Les Produits Bridor, Inc. (Boucherville, Quebec, Canada) for their collaboration to this study, as well as Carmelle Perron and Michèle Grenier from the FRDC respectively for help during the preparation of the manuscript and some statistical analyses.

LITERATURE CITED

EDELMANN, K., STELWAGEN, P., and OURA, E. 1981. The influence of temperature and availability of oxygen on the carbohydrates of stored baker's yeast. Pages 51-56 in: Current Developments in Yeast Research. G. G. Stewart and I. Russell, eds. Pergamon Press: Toronto.

GÉLINAS, P., FISET, G., LEDUY, A., and GOULET, J. 1989. Effect of growth conditions and trehalose content on cryotolerance of bakers' yeast in frozen doughs. Appl. Environ. Microbiol. 57:463-468.

GÉLINAS, P., LAGIMONIÈRE, M., and DUBORD, C. 1993. Baker's yeast sampling and frozen dough stability. Cereal Chem. 70:219-225.

GOUX, J., and CLÉMENT, P. 1987. Levures surgelées en particules fluides s'écoulant librement, procédé pour les obtenir et application de ces levures aux pâtes congelées. European patent application 0 237 427 A2.

HAHN, Y.-S., and KAWAI, H. 1990. Screening of freeze-tolerant yeasts from nature available for the frozen-dough method. Agric. Biol. Chem. 54:829-831.

HICKS, C. R. 1982. Fundamental Concepts in the Design of Experiments, 3rd ed. Saunders College Publishing: Fort Worth, TX.

HINO, A., TAKANO, H., and TANAKA, Y. 1987. New freeze-tolerant yeast for frozen dough preparations. Cereal Chem. 64:269-275.

HSU, K. H., HOSENEY, R. C., and SEIB, P. A. 1979. Frozen dough. I. Factors affecting stability of yeasted doughs. Cereal Chem. 56:419-424.

KLINE, L. , and SUGIHARA, T. F. 1968. Factors affecting the stability of frozen bread doughs. I. Prepared by the straight dough method. Baker's Dig. 42(5):44-46, 48-50.

MONTGOMERY, D. C. 1991. Design and Analysis of Experiments, 3rd ed. John Wiley & Sons: New York.

TANAKA, Y., KAWAKAMI, K., and TAKANO, H. 1980. Effect of pre-storage of compressed baker's yeast in frozen dough. (In Japanese.) Rep. Natl. Food Res. Inst. 36:64-71.

TRIVEDI, N., HAUSER, J., NAGODAWITHANA, T., and REED, G. 1989. Update on bakers' yeast. Am. Inst. Baking Technol. Bull. 11(2):1-5.

VAN HORN, D. 1989. Cream yeast. Pages 144-153 in: Proc. Ann. Mtg. Am. Soc. Bakery Eng., 65th. The Society: Chicago.

[Received July 7, 1993. Accepted November 16, 1993.]